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RESULTS OF BOREHOLE GEOPHYSICAL TESTING
AT THE HAVERTOWN PCP SITE
HAVERTOWN, PENNSYLVANIA

REWAI Project 86021

Presented to

Pennsylvania Department of Environmental Resources
Harrisburg, PA

August 1989

r.e. wright associates, inc.
earth resources consultants

middletown, pa.

AR300834

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Prepared by

R. E. WRIGHT ASSOCIATES, INC.
3240 Schoolhouse Road
Middletown, PA 17057

August 1989

Respectfully submitted,

Gregory J. Burgdorf

Gregory J. Burgdorf, P.G.
Project Manager/Geophysicist

Reviewed by:

Raymond S. Lambert

Raymond S. Lambert, P.G.
Project Director

Carl G. Boyer/JK

Carl G. Boyer, P.G.
Project Director

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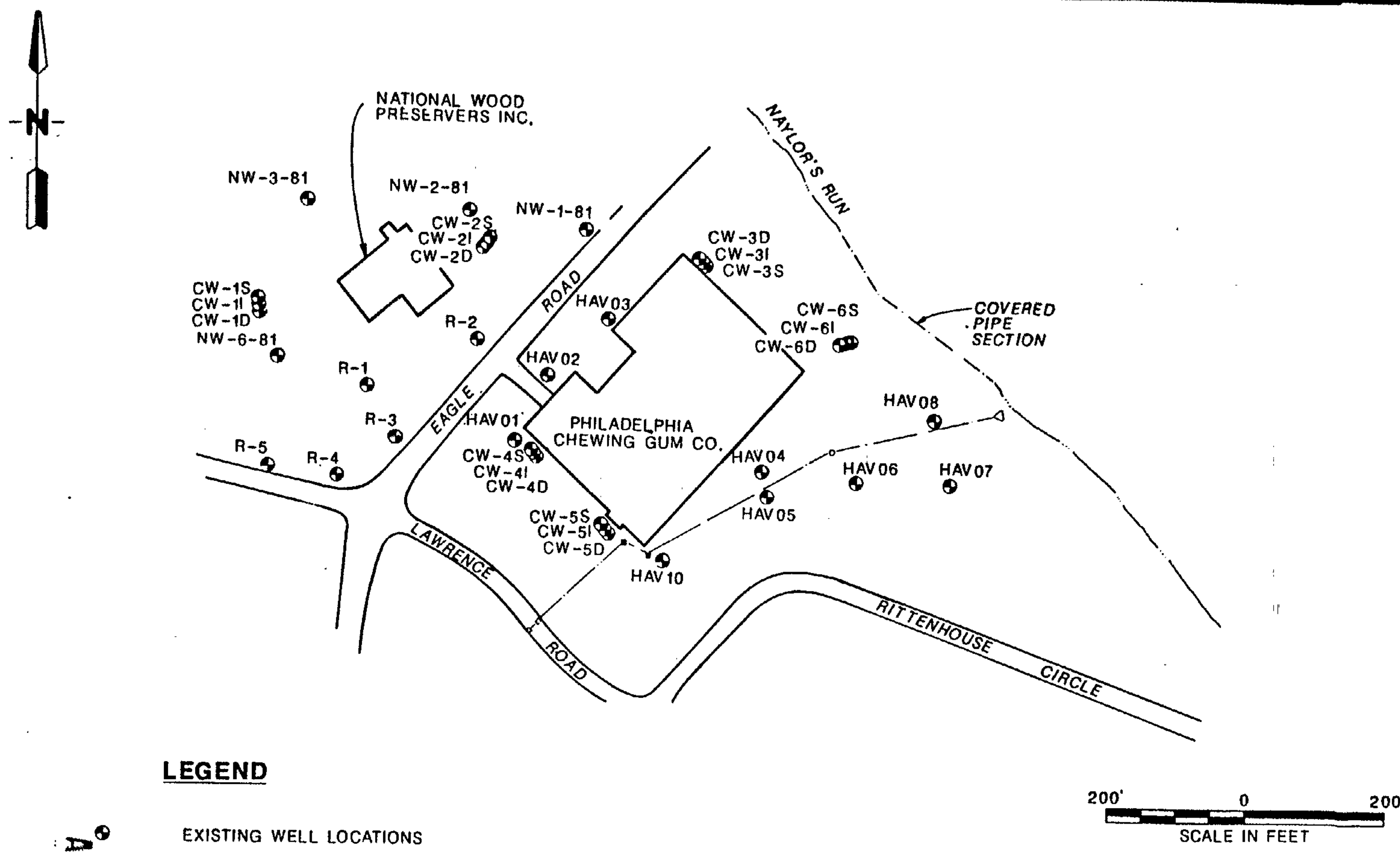
INTRODUCTION

On March 28 and 29, 1989, borehole geophysical logging was completed in nine groundwater monitoring wells at the Havertown PCP Superfund site in Havertown, Pennsylvania. Appalachian Coal Surveys of Pittsburgh, Pennsylvania, performed the logging of wells CW-4D, R-1 to R-5, NW-1, NW-2, and NW-3 under the supervision of Mr. Gregory Burgdorf and Mr. Eric Roof of R. E. Wright Associates, Inc. (REWAI). Locations of the logged wells are shown on Figure 1. The logging was conducted to identify the lithology and relative hydraulic conductivities of the subsurface materials penetrated by the well bore and determine well construction features. Because each well is constructed of polyvinyl chloride (PVC) casing and screens, the logging techniques consisted of the following methods: natural gamma, high resolution density, formation (gamma-gamma) density, neutron and fluid conductivity. These techniques were able to measure the physical properties of the formation and annulus materials outside of the PVC casing and screen.

GEOPHYSICAL LOGGING METHODS

Borehole geophysical logging of the subsurface involves the lowering of sensing instruments into a well and obtaining a continuous record of the physical characteristics of the subsurface over the well depth. The logs are then interpreted to determine physical and chemical characteristics of the rock strata and borehole fluids with different logging techniques responding to different physical/chemical properties of the surrounding medium.



LEGEND

EXISTING WELL LOCATIONS

STORM SEWER

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FIGURE 1

HAVERTOWN PCP SITE
HAVERTOWN, PA

MONITORING WELL LOCATIONS

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The natural gamma log responds to the amount of natural gamma radiation emitted by the materials filling the well annulus and the surrounding rock and is used as a lithology indicator. The natural gamma tool operated by Appalachian Coal Surveys was a scintillometer type, utilizing a sodium iodide detector. This tool can be used in cased or uncased wells, above or below the water level. Because most naturally occurring radioactive isotopes are associated with clay minerals, the natural gamma log is used as a clay or shale indicator. At the Havertown site, however, the natural gamma responses are believed to be elevated due to above normal radioactivity associated with the metamorphic rock beneath the site. Therefore, sandy intervals will respond with a higher gamma count, falsely indicating a greater percent of clay in the interval than the amount that actually occurs. This site-specific characteristic must be considered in the evaluation of the natural gamma logs.

The high resolution and formation (gamma-gamma) density tools both measure the response of radioactive isotopes inducted into the casing, annulus materials, and subsurface formation. Induced gamma rays are reflected by the material in the borehole at a rate inversely proportional to the density of the material. The reflected gamma rays are measured by the tool. The high resolution density measures the density of the well casing and penetrates outward to a distance of approximately 0.05 feet outside of the casing. This density technique uses a small radioactive source (Americium 241), located in the density tool. Dense materials such as lead absorb gamma rays, and lighter materials such as sand reflect gamma rays back to the instrument. The formation density tool uses a radium 226 source, which permits density logging through thin-walled casing into the formation. Due to the PVC casing and varied annulus material in each well, the density tool can measure only relative formation density to determine porosity and the lithology of subsurface materials. Responses to this density tool are also influenced by the water level in the well.

The neutron tool measures the hydrogen content of the surrounding rock and subsurface materials. It is used to identify the lithologic composition and water content of subsurface materials, and also is an indicator of relative formation porosity. The neutron tool used was a neutron-neutron type, utilizing a lithium iodide crystal detector and a neutron-generating (AM_{241}/ beryllium) source. Because most hydrogen is neutron deficient, the generated neutrons are readily absorbed by water and/or hydrocarbons. The water or hydrocarbon saturation of the logged rock of the borehole wall is inferred from the frequency of reflected neutrons. This tool can be run through casing; however, the log response is highly affected by water levels in the well casing.

The fluid conductivity tool measures the conductivity of borehole fluid by continuously drawing small volumes of the fluid into an isolated chamber within the tool. The fluid completes an electrical circuit between two electrodes in the chamber. Changes in the resistance of the circuit generates the log response. This tool is used to identify changes in water quality, groundwater entry points in the well bore, and determine hydrocarbon water thickness an water depth in the well.

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INTERPRETATION OF RESULTS

Nine monitoring wells were logged at the Havertown site which includes CW-4D, R-1 to R-5, NW-1, NW-2, and NW-3 (Figure 1). With the exception of well CW-4D, these wells were selected due to the lack of stratigraphic and well construction information for the wells. A second purpose for logging was to compare relative formation hydraulic conductivity and porosity with the presence or absence of oil in the wells. Such comparisons included the clay content of the saprolite interval and thickness of porous zones in each well. All depths presented in this report are referenced from top of well casing. Interpretations of the logs from each of the various logging techniques for each well are discussed below. Appalachian Coal Surveys contributed to the interpretation of the geophysical interpretation. Copies of the geophysical logs for each well are provided in pockets at the end of this report. A summary of interpreted stratigraphy and well construction characteristics for each well, based on geophysical logs, is provided on Table 1. Available geologic and well construction logs of the logged wells are in Appendix A.

Well CW-4D

Well CW-4D was selected as a log response control well due to known stratigraphy and well construction details. During the logging program, the well had a total depth of 49 feet and a static groundwater level of 13 feet below top of casing. The formation stratigraphy, based on combined geophysical logs, is interpreted as follows:

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TABLE 1

Summary of Interpreted Stratigraphy and Well Construction
Features of Logged Monitoring Wells from Geophysical Logging

				Stratigraphy			Well Construction		
Well No.	TD (ft)	Depth to SWL (TOC) (ft)	Product Thickness (ft)	Saprolite Interval (TOC) (ft)	Average Clay Content of Saprolite (%)	Bedrock Interval (TOC) (ft)	Fill/Grout Interval (TOC) (ft)	Bentonite Interval (TOC) (ft)	Sand Pack Interval (TOC) (ft)
CW-4D	49	13	0.0	3 - 26	35	26 - 49	3 - 30	30 - 35	35 - 49
R-1	35	23	0.0	3 - 32	35	32 - 35	3 - 17	17 - 22	22 - 35
R-2	29	20	6.5	3 - 24	45	24 - 29	3 - 6.5	6.5 - 9	9 - 29
R-3	33	23	10.0	3 - 32	45	32 - 33	3 - 10.5	10.5 - 18	18 - 33
R-4	35	21	0.0	2 - 34	85	34 - 35	2 - 11	11 - 21.5	21.5 - 35
R-5	30	24	0.0	3 - 30	50	--	3 - 16.5	16.5 - 19	19 - 30
NW-1	21	13	0.0	3 - 21	95	--	3 - 5.5	5.5 - 9.5	9.5 - 21
NW-2	22	13	0.0	3 - 22	45	--	3 - 4.5	4.5 - 6.5	6.5 - 22
NW-3	21	8	0.0	3 - 16	60	16 - 21	3 - 4.5	4.5 - 8.5	8.5 - 21

Notes:

TD - Total Depth of Well
SWL - Static Groundwater Level
TOC - Top of Casing
-- - Bedrock Not Encountered in Well.

Due to geophysical tool construction, upper limit of logged interval is 2 or 3 feet below top of casing.

Depth (Feet)	Lithology
3 to 26	Sandy saprolite.
26 to 49	Gneiss, porous weathered zones at 32 to 34, and 38 to 39 feet; dense high gamma layer at 41 to 46 feet.

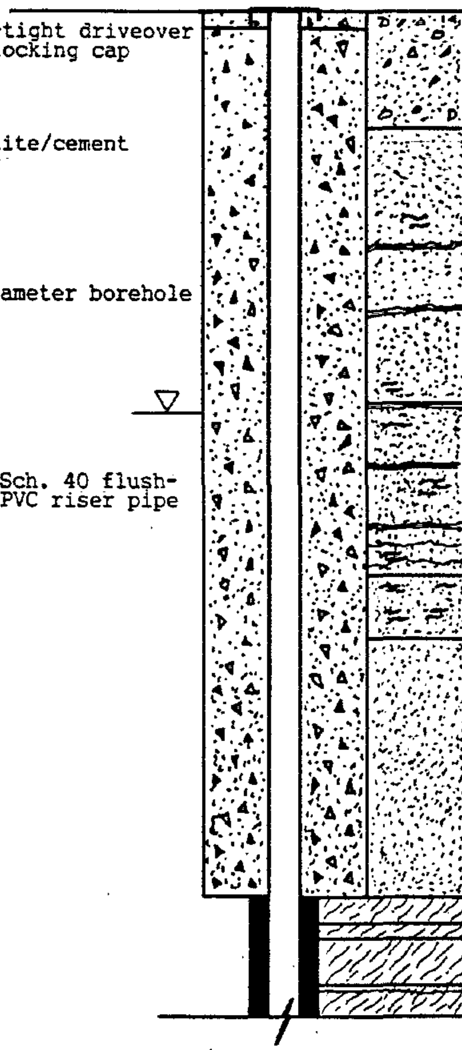
This stratigraphic interpretation correlates with the visual description of the material encountered by REWAI during monitoring well installation (Figure 2). The saprolite interval above the unweathered schist bedrock is interpreted to be very sandy which correlates with the relatively low neutron and natural gamma responses. The two weathered zones previously described within the unweathered schist bedrock were identified as fractured zones. The dense, high gamma layer from 41 to 46 feet correlates with a pegmatite interval.

The neutron log response in well CW-4D averaged between 300 to 500 counts per second (cps) in the gneiss interval. The lowest neutron measurements in the bedrock were encountered at depths of 32 to 34 feet and 38 to 39 feet. The dense pegmatite layer from 41 to 46 feet had a high neutron measurement of greater than 1,000 cps indicating dense, nonwater-bearing properties. Based on the natural gamma response, the sandy saprolite interval (3 to 26 feet) is interpreted to have a clay content of about 35 percent. A neutron response of 200 cps was detected throughout most of this sandy interval.

The fluid conductivity response of 19 ohm-meters indicated that no hydrocarbon accumulation was detected in this well.

Havertown PCP Site
Project 86021
Monitoring Well CW-4D

Depth Below Ground Surface	Blow Counts	Field VOA Analysis (ppm)	Well Construction Information
0' (305.6)	6 5 5 5 4 3 3 3	B, B	Water-tight driveover with locking cap
6' (299.6)	6 12 14 20 15 18 18 20 16 20 18 20 19 18 18 22	B, B, B, B	Bentonite/cement slurry; 10" diameter borehole
12' (293.6)	8 9 18 23 8 16 24 30 14 18 20 20	B, B, B	2" ID Sch. 40 flush-joint PVC riser pipe
18' (287.6)	10 26 26 29 9 14 16 28 10 13 19 24	1.5, B, B	
24' (281.6)	14 21 30 40 14 78 100/3"	B, B	
30' (275.6)	ROCK		
32' (273.6)	CORED		



USCS* Symbol	Description
Fill	Moderate yellowish-brown to dark yellowish-brown, fine to medium-grained SAND, weathered, highly micaceous, little cinders, trace schist fragments, moist, fill.
SP	Olive gray and dark gray, very fine to medium-grained SAND, micaceous, highly weathered, trace quartz/feldspar veins, foliation abundant and dipping 40°-50°, moist to saturated, micaceous saprolite.
SP-SM, SP	Grayish-brown to dark yellowish-brown, very fine to medium-grained SAND, trace of silt, trace manganese-coated fractures, highly weathered, foliation present only from 26'-28' dipping 30°, saturated, biotite-muscovite schist(?) saprolite.
Bedrock	Olive gray to medium gray, heavily broken, moderately weathered, foliation dipping 30°, biotite-quartz-feldspar gneiss.

Continued on next page

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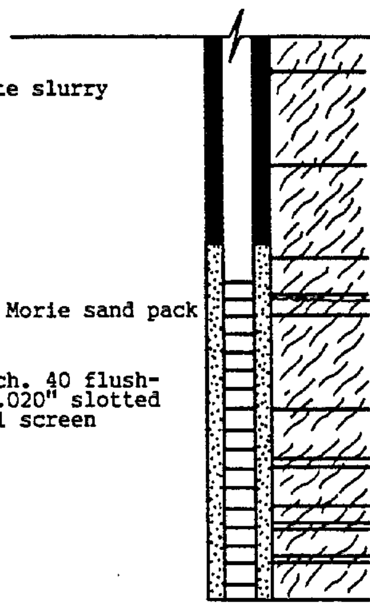
Havertown PCP Site
Project 86021
Monitoring Well CW-4D (cont'd)

Depth Below Ground Surface	Blow Counts	Field VOA Analysis (ppm)	Well Construction Information	USCS* Symbol	Description
32' (273.6)	ROCK CORED		Bentonite slurry	Bedrock	Olive gray to medium gray, heavily broken, moderately, weathered, foliation dipping 30°, biotite-quartz-feldspar gneiss.
36' (269.6)		NA	Grade 1 Morie sand pack		
42' (263.6)			2" ID Sch. 40 flush-joint 0.020" slotted PVC well screen	Pegmatite	White, hard, very slightly weathered quartz, feldspar, biotite, pegmatite.
				Bedrock	Medium gray and black, hard, slightl weathered, biotite-quartz-feldspar gneiss.
				Pegmatite	White and dark yellowish-orange, har slightly weathered, quartz, feldspar biotite pegmatite.
48' (257.6)				Bedrock	Medium gray and black, foliation dipping 30°, biotite-quartz-feldspar gneiss, as above.
50' (255.6)					



Vertical Scale: 1" = 6'

Total Depth of Well: 50'
Bedrock Elevation: 277.6'
Borehole Diameter: 10"/4"
Monitoring Tube Diameter: 2" - 20 slot
Slotted Casing Interval: 265.6' - 255.6'
Elevation Top of Casing: 305.66'

Elevation Ground Surface: 305.6'
SWL Elevation (3/17/88): 292.74'
Drilling Company: Empire Soils Investigations
Drilling Began: 2/22/88
Drilling Completed: 2/24/88
Geologist: John N. Ward

*Unified Soil Classification System
NA - Not Analyzed
B - Background

(305.6) elevation relative to mean sea level

Responses of the natural gamma and high resolution density log of well CW-4D suggest that the following materials are present in the annulus space between the borehole wall and the PVC casing. Field construction details are also given below for comparison purposes.

Geophysical Interpretation		Field Construction	
Depth (Feet)	Annular Materials	Depth (Feet)	Annular
3 to 30	Cement grout	0 to 28	Cement Grout
30 to 35	Bentonite	28 to 38	Bentonite
35 to 49	Sand pack	38 to 50	Sand Pack

Well R-1

Well R-1 had a total depth of 35 feet and a static water level of 23 feet below top of casing. Interpretation of the borehole geophysical logs indicate the following stratigraphy for well R-1:

Depth (Feet)	Lithology
3 to 21	Fill and clayey saprolite.
21 to 32	Sandy saprolite.
32 to 35	Unweathered schist.

The top 20 feet of the well appears to correlate with fill material which was encountered during drilling. No distinct porous water-bearing zones are identified by the neutron log. Neutron response in the saprolite zone was approximately 310 cps with approximately 360 cps measured in the unweathered schist zone at the bottom of the well. An estimated clay content of 30 to 40 percent was indicated in the saprolite by the natural gamma log.

Variation of the formation density response in the saprolite and unweathered bedrock intervals below the water table was approximately 1500 cps. This response variation indicates a significant difference in density between the saprolite and bedrock intervals. A uniform fluid conductivity of 25 ohm-meters was detected in the water in the borehole, indicating that no hydrocarbons are present in the well bore.

Based on the responses of the logging techniques, the construction of well R-1 is as follows:

Geophysical Interpretation

Depth (Feet)	Annular Materials
3 to 17	Cement grout, broken from 4 to 14.5 feet.
17 to 22	Bentonite (seal 6 feet lower than indicated on well construction log).
22 to 35	Sand pack.

Depth (Feet)	Original Well Log
15 to 16	Bentonite grout
16 to 39	Sand pack

Well R-2

Well R-2 had a total depth of 29 feet. The static water level in the well was 20 feet below top of casing. Based on the log responses, the stratigraphy in well R-2 is as follows:

Depth (Feet)	Lithology
3 to 24	Saprolite, slightly sandy from 9 to 12 feet and 23 to 24 feet, semi-porous from 21.5 to 24 feet, clay layer at 17.5 to 18 feet.
24 to 29	Unweathered schist.

A neutron measurement of 250 cps was detected from a depth of 21 to 24 feet indicating a porous, water-bearing interval. This relatively low neutron response from 21 to 24 feet is one of the lowest neutron measurements encountered at the site, suggesting a higher relative hydraulic conductivity in the subsurface materials. From 24 to 29 feet, the average neutron measurement was approximately 400 cps, indicative of an unweathered schist layer at the bottom of the well.

The natural gamma response indicates a clay content of approximately 45 percent in the 21 to 24 feet depth interval. Variation of formation density measurements of the saprolite and unweathered schist intervals was about 900 cps.

The fluid conductivity response indicates an accumulation of floating product (hydrocarbons) at the fluid surface in the well, with a thickness of 6.5 feet. The conductivity of the hydrocarbons was greater than 500 ohm-meters.

The annulus material in well R-2 is as follows:

Geophysical Interpretation		Original Well Log	
Depth (Feet)	Annular Materials	Depth (Feet)	Annular Materials
3 to 6.5	Cement grout	5.5 to 7.5	Bentonite grout
6.5 to 9	Bentonite	7.5 to 29	Sand pack
9 to 29	Sand pack		

Well R-3

The total measured depth of well R-3 was 33 feet below top of casing with a static water level of 23 feet. The well's stratigraphy is interpreted as follows:

Depth (Feet)	Lithology
3 to 32	Saprolite, slightly sandy from 27 to 30.5 feet, clay layer at 22 to 23 feet.
32 to 33	Unweathered schist.

The average neutron response below the water table averaged approximately 260 cps with a high count of approximately 350 detected at a depth of 30 feet. No distinctly porous zones were identified by the neutron log. A clay content of about 45 percent is estimated at a depth of 27 to 30.5 feet. A formation density response variation of about 1,100 cps was measured between the saprolite and unweathered schist which is a typical response between the intervals.

The fluid conductivity response indicated hydrocarbon accumulation of 10 feet in the well, underlain by approximately 0.5 feet of water.

Based on the response of the high resolution density and natural gamma logs, the materials in the annulus of well R-3 are as follows:

Geophysical Interpretation		Original Well Log	
Depth (Feet)	Annular Materials	Depth (Feet)	Annular Materials
3 to 10.5	Cement grout	13 to 14	Bentonite grout
10.5 to 18	Bentonite	15 to 35	Sand pack
18 to 33	Sand pack		

Well R-4

Well R-4 had a total depth of 35 feet below top of casing with a static water level of 21 feet. Based on the response of the geophysical logs, the following stratigraphy is estimated:

Depth (Feet)	Lithology
2 to 34	Saprolite, clayey from 8 to 21 feet and 23 to 34 feet.
34 to 35	Unweathered schist.

The neutron and formation density data indicate relatively impermeable, clayey subsurface materials. The average neutron counts at a depth of 21 to 26 feet was approximately 320 cps, and approximately 420 cps from 28 to 32 feet. Below 32 feet, an average neutron response was at 360 cps. The formation density response was relatively uniform in the saturated subsurface materials.

The natural gamma log indicates a clay content of 80 to 90 percent throughout most of the logged formation. The interval from 21 to 23 feet has an estimated clay content of 65 percent.

A variation in the fluid conductivity response at a depth of 31 to 32 feet suggests a groundwater entry zone at this depth in well R-4. Conductivity values of 45 to 60 ohm-meters were detected in the well fluid. No floating product accumulation was detected.

According to the geophysical logs, the annulus of well R-4 is constructed as follows. A log of this well is not available.

Depth (Feet)	Annular Materials
2 to 11	Cement grout.
11 to 21.5	Bentonite.
21.5 to 35	Sand pack.

Well R-5

At the time of the geophysical logging, well R-5 had a total depth of 30 feet and a static water level of 24 feet below top of casing. The following stratigraphy is interpreted in the well:

Depth (Feet)	Lithology
3 to 30	Saprolite, sandy from 19 to 25 feet.

The neutron response indicates a relatively permeable subsurface material from a depth of 24 feet to the bottom of the well. An average neutron response of 220 cps was detected in this interval. The formation density measurement gradually decreases in counts with depth, suggesting increasing formation density with depth.

From 19.5 to 30 feet, the clay content of the subsurface material ranges from 35 to 60 percent, as determined by the natural gamma log. As uniform conductivity value of 30 ohm-meters was measured in the well's fluid, no floating product accumulation was indicated.

Responses of the geophysical logs indicate that the following materials are present in the annulus of well R-5. A log of this well is not available.

Depth (Feet)	Annular Materials
3 to 12.5	Fill material
12.5 to 16.5	Cement grout

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16.5	to 19	Bentonite
19	to 30	Sand pack

Well NW-1

Well NW-1 had a total depth of 21 feet below top of casing and a static water level of 13 feet. Interpreted stratigraphy of well NW-1 is as follows:

Depth (Feet)	Lithology
3 to 21	Saprolite or possibly fill, very clayey, becoming denser with depth, potential water-containing zone at 13 to 13.5 feet.

This well had the highest gamma count detected in this logging program. A gamma count of greater than 100 cps was detected in the well bore from a depth of 5 to 9 feet and 17 to 18 feet. Elevated natural gamma response were measured throughout the entire well bore with the estimated percentage of clay greater than 90 percent. A neutron count of 300 cps was related at a depth of 13 feet; however, this neutron response rapidly increased to 800 cps at the bottom of the well at a depth of 20 feet. This response suggests that the formation in this well may represent an impermeable clay. The upper portion of the saturated unit, at depth of about 13 to 14 feet, contributes most of the water found in this well. The relative hydraulic conductivity of subsurface materials near well NW-1 are interpreted to be very low.

The fluid conductivity response was relatively uniform, with a slight increasing value with depth. Values of conductivity ranged from 55 to 65 ohm-meters in this well. No floating product is indicated.

According to the geophysical logs the annulus of well NW-1 has the following well construction:

Geophysical Log Interpretation		Original Well Log (Depth Feet)	
Depth (Feet)	Annular Materials	Depth (Feet)	Annular Materials
3 to 5.5	Cement grout	3 to 4	Bentonite grout
5.5 to 9.5	Bentonite	4 to 25	Sand pack
9.5 to 21	Sand pack		

Well NW-2

A total depth of 22 feet below top of casing was measured in well NW-2 with a static water level of 13 feet. The following stratigraphy is interpreted:

Depth (Feet)	Lithology
3 to 22	Saprolite to semi-weathered schist, less weathered below 13 feet, sandy from 12 to 14.5 feet.

An average neutron count of approximately 380 cps was detected from 14 to 18 feet. From 14 to 22 feet, the average neutron response was approximately 330 cps. The formation density tool had a similar response with less dense material occurring at a

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depth below 14 feet. A porous, water-bearing zone may occur at a depth of 19 feet.

The natural gamma response indicates clay contents of approximately 45 percent above 14 feet and 60 to 70 percent below 14 feet. A uniform conductivity value of 25 ohm-meter was measured.

The placement of annular materials in this well are interpreted as follows:

Geophysical Log Interpretation		Original Drilling (Depth Feet)	
Depth (Feet)	Annular Materials	Depth (Feet)	Annular Materials
3 to 4.5	Cement grout	2 to 3	Bentonite grout
4.5 to 6.5	Bentonite	3 to 24	Sand pack
6.5 to 22	Sand pack		

Well NW-3

Well NW-3 has a total depth of 21 feet below top of casing with a measured static water level of 8 feet. The following stratigraphy is determined:

Depth (Feet)	Lithology
3 to 16	Saprolite, sandy from 9.5 to 16 feet.
16 to 21	Weathered schist.

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The neutron measurement indicates relatively permeable subsurface materials. At a depth of 9 to 16 feet in the saprolite, the average neutron response was approximately 200 cps. An average neutron response of 260 cps was determined from 16 to 21 feet. The formation density curve correlates with the changes in the neutron measurements, indicating less dense material above 16 feet.

The percentage of clay from the natural gamma response from 9 to 16 feet is approximately 50 percent with a 70 to 80 percent clay content below a depth of 16 feet. The fluid conductivity response indicated a uniform groundwater conductivity of 65 ohm-meters.

The following well construction is determined:

Geophysical Interpretation		Original Well Log	
Depth (Feet)	Annular Materials	Depth (Feet)	Annular Materials
3 to 4.5	Cement grout	2 to 3	Bentonite grout
4.5 to 8.5	Bentonite	3 to 24	Sand pack
8.5 to 21	Sand pack		

SUMMARY OF INTERPRETATIONS

Based on the responses of the five different logging techniques used in this borehole geophysical investigation at the Havertown site, information was determined on the stratigraphy and relative hydraulic conductivity of the subsurface materials and well construction features. This data can be used to further define the site-specific groundwater and hydrocarbon transport mechanisms in the subsurface. A summary of the geophysical results and well construction information of the nine logged monitoring wells is given in Table 1.

Interpretation of the geophysical logs indicate that the stratigraphy of the site subsurface consists of a saprolite interval of varying percentages of clay and sand overlying the unweathered schist and gneiss bedrock. The average thickness of the saprolite interval is approximately 28 feet. Thin clay layers in the saprolite can be correlated between wells R-2 and R-3. Subsurface materials of wells NW-1 and NW-2 are similar and have the highest clay content of the logged wells.

The neutron and formation density tool responses indicate that wells CW-4D, R-5, R-2, and NW-3 (in order) have the higher relative hydraulic conductivities. The higher hydraulic conductivity interpreted for well R-2 may be an explanation for the occurrence of hydrocarbons in this well. Although well R-5 appears to have the highest hydraulic conductivity of all the wells logged, its location is apparently outside the area of hydrocarbon accumulation.

Logging results indicate that wells NW-1, NW-2, and R-4 penetrate subsurface materials which exhibit the lowest hydraulic conductivity values. Well NW-1 is interpreted to have penetrated a varied clay sequence with low hydraulic conductivity. This condition may be an explanation for the absence of hydrocarbons in the well.

In most wells, the well construction details determined from borehole geophysical logging correlates with available information. Locations of cement grout, bentonite seal layers, and sand pack was easily determined by the high resolution density and natural gamma logs. Discrepancies with respect to the position of bentonite seals or thickness of sand pack were revealed in most wells. For example, the bottom of the bentonite seal in well R-1 was found to be six feet lower in depth than was identified in the available well construction log. This condition could impede the migration of hydrocarbons into this well by direct blockage or by entering the screened interval and becoming lodged in the slots at depth.

The findings of the geophysical testing of the monitoring wells at the Havertown PCP site has provided additional information on the stratigraphy and physical properties of the penetrated subsurface materials. The relative clay content of the subsurface materials of each well was estimated. These estimates can provide relative hydraulic conductivity projections for the various materials. The information obtained from this investigation should be used in the placement and design of monitoring/recovery wells if additional groundwater or oil product recovery testing is to be conducted.

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DESCRIPTION OF IMAGERY Borehole Log

NUMBER AND TYPE OF IMAGERY ITEM(S) 1 oversized map

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DESCRIPTION OF IMAGERY Borehole Logs

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